Chapter 1

A tonological rarity: Tone-driven epenthesis in Ghomala'

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This chapter focuses on a little-known tonological rarity: tone-driven vowel epenthesis. In Ghomala' (Grassfields, Bantoid: Cameroon), an epenthetic vowel is inserted to avoid a rising tone on a syllable closed by an obstruent, i.e. /gŏp/ → [gɔ̀pɔ́] 'hen'. Epenthesis is never triggered in other tonal contexts (e.g. /kɔ́p/ → [kɔ́p] 'pot', *[kɔ́pɔ́]; /bɔ̂p/ → [bɔ̂p] 'thorax', *[bɔ́pɔ̀]), revealing that epenthesis cannot be attributed to segmental or syllabic well-formedness. Moreover, active alternations show that when a rising tone is changed the epenthetic vowel is also lost, illustrating complete co-variation. This paper explicates each of these points, and demonstrates that they support an independent proposal in the tone and Africanist literature: contrastive tonemes should be deconstructed into tonal features. Finally, we highlight that while the motivation for this process is quite common (avoiding a rising tone on a sub-optimal host), the repair itself (i.e. epenthesis) is virtually unprecedented in the tone literature. We discuss three explanations for its rarity, specifically contrasting it against intonation where it is more common: (i) the low functional load of tone, (ii) the analytic indeterminacy of epenthesis, and (iii) the potential to find pre-existing hosts. These factors conspire to make tone-driven epenthesis a tonological rarity.

1 Introduction

What kind of tones, tone systems, and tonological operations are common in the world's tonal languages and which are rare? While there has been considerable focus on common vs. rare phenomena in non-tonal phonology – e.g. with regard to consonants (Butskhrikidze 2010; Tuttle 2010) or stress/accent (Helmbrecht 2010), both within Wohlgemuth & Cysouw (2010)'s volume on 'rara and rarissima' – less attention has been paid to considering the same for tone.

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Even though its literature is small, certain tonological rarities are known at this point. Languages with three to four heights are common enough (e.g. low, mid, and high) but systems with five heights are rare and six virtually unattested (Yip 2002; Odden 2020). Moreover, tonal operations like downstepping are quite common while 'upstep' is attested (Snider 1990) but much rarer, and various asymmetries are established with regard to anticipatory vs. regressive tone assimilation (see Hyman 2007 for an extensive survey). Certain tonal patterns are rare (and contentious) enough to generate a literature unto themselves, e.g. the famous Xiamen/Southern Min tone circle in its tone sandhi system (Dong 1960; Chen 2000; Zhang et al. 2006).

The specific focus for this chapter will be on tone/segment interactions. Some of these are known to be quite common such as consonant depression from voiced consonants, while others quite rare such as tone dependent on vowel height (Jiang-King 1999; Yip 2002) and tone affecting segmental features generally (Wee 2019). What we will show is an even rarer case: the insertion of a vowel itself in order to host a tone.

Within the intonation literature this process is well-known, situated within larger discussion of 'text-tune' relationships. In cases where there is a mismatch between the segmental structure (the 'text') and the intonational melody (the 'tune'), normally it is the melody which accommodates (e.g. through truncation). However, a growing literature has shown evidence for the opposite: segmental structure changing to accommodate the intonation (Roettger 2017; Grice et al. 2018; Roettger & Grice 2019).

To illustrate, consider a recent study of Tunisian Arabic intonation (Hellmuth 2022). Yes-no questions are commonly realized with a rise-fall intonational complex (i.e. L*+H H-L%) at the right edge of an intonational phrase. When this intonational complex appears, it often co-occurs with an epenthetic vowel to which part of this complex docks. An example of such epenthesis is in (1).

(1) nkemmil tˤuːl   →   [nkemmil tˤuːləː]
     I-continue straight.ahead
     'Should I go straight ahead?' (Hellmuth 2022)

Hellmuth is explicit that epenthesis only appears in the context of this complex rise-fall contour, and even then only half the time. Importantly, it *never* appears when there is only a simple rise or simple fall, even in the context of a yes/no question. Tunisian Arabic thus shows clear co-variation between a final vowel and a complex pitch event.

If such epenthesis is rare in intonation, then it is practically unprecedented

in tonal languages, which make lexical and grammatical use of tone (Blumenfeld 2006; Gleim 2019; Rolle & Merrill 2022). Despite the general rarity of this process, we argue that this is exactly what is found in the tonal language Ghomala' based on a variety of arguments from both root structure and active alternations in multi-morphemic contexts. Here and throughout, we refer to this as 'tone-driven epenthesis' (and its intonational counterpart as 'intonation-driven epenthesis'). Epenthesis in both cases can be attributed to functional pressures to cultivate segmental environments best suited for realizing pitch targets.

This paper will systematically go through these issues, and is organized as follows. Section 2 provides the necessary background on the Ghomala' language and its tone system, and Section 3 presents are evidence for tone-driven epenthesis in Ghomala' as well as an unexpected ramification, namely support for tonal features. Following this, Section 4 provides discussion, consisting of situating the Ghomala' patterns within a wider typology of constraints on rising tone contours, the pronounced rarity of an epenthetic repair in the face of such constraints, and three possible explanation for its rarity. Section 5 provides a conclusion.

2 The Ghomala' language

Ghomala' (pronounced [ɣɔ̀málá̰ʔ], also called Bandjoun/Banjun – ISO 639-3: bbj) is a Bamileke language of the Grassfields family spoken in Western Cameroon, and part of the wider Niger-Congo phylum. Data for this study come largely from grammatical description in Nissim (1972; 1981) and the dictionary of Eichholzer (2010). The data relevant to tone-driven epenthesis is confirmed by other publications on Ghomala' including Ntagne & Sop (1975) and Piron (1997), as well as field recordings made by Nissim (from Hyman p.c.). In order to keep our discussion clear and focused, we largely concentrate on the nominal system and leave aside the verbal system.[1]

As in Grassfields generally, Ghomala' has both a rich set of consonantal contrasts and vocalic contrasts.[2] Relevant for our discussion are the consonants

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[1]Two other sources on Ghomala' may be relevant. The first is an academic paper on Ghomala' locatives in Domché-Téko (2000), and the second are YouTube videos made by Ghomala' language advocates. Some data within these resources appear to confirm the central facts of the other sources, while other data *prima facie* challenge it. It is unclear at this point the exact role that variation (or dialect differences) plays in these matters, and this chapter hopes to spur on further study to sort this out.

[2]Ghomala' transcriptions follow the IPA except for c=[tʃ], j=[dʒ], š=[ʃ], ž=[ʒ], y=[j], ẅ=[ɥ], ʉ=[ʉ]~[ɯ], and ɑ=[ɐ] (note that a=[a]). See Nissim (1981: 45-71) for their phonetic details.

which can appear in coda position, which are /m ŋ p k ʔ/. Certain properties of these consonants and vowels will be brought up as they become relevant. At an abstract level of analysis Ghomala' makes a central distinction between high (H) and low (L) tones, though in practice there are numerous surface heights and contours.

To illustrate the tone system, consider the open monosyllabic roots in Table 1. Here, a basic six-way distinction can be discerned by comparing isolation pronunciations to those in object position. There are two types of high tones, one consistently realized as high (a., labeled H) and one which is realized high in isolation but in context surfaces as a downstepped high (b., ꜜH). Likewise, there are two types of low tones, one realized as a level low tone which does not fall to the lowest part of the pitch range (c., conventionalized as L° with a degree symbol), versus a low which does fall to the lowest part of the pitch range (d., simply L). Finally there are two contours, one a LH tone which is realized rising in isolation but may also be realized as a downstepped high in certain contexts (e.), as well as a HL tone realized falling in both contexts (f.).

Table 1: Tone contrasts on open monosyllabic roots (Nissim 1981: 150, 153)

	Tone	Isolation		Context	
a.	H	**fɑ́**	'parent'	ŏ ꜜyɔ́ **fɑ́**	'you saw the parent'
b.	ꜜH	**dhə́**	'spouse'	ŏ ꜜyɔ́ ꜜ**dhə́**	'you saw the spouse'
c.	L°	**tsə̀°**	'cola nut'	ŏ ꜜyɔ́ **tsə̀°**	'you saw the cola nut'
d.	L	**tà**	'pot'	ŏ ꜜyɔ́ **tà**	'you saw the pot'
e.	LH	**bvǔ**	'dog'	ŏ ꜜyɔ́ ꜜ**bvǔ**	'you saw the dog'
f.	HL	**bʉ̂**	'madman'	ŏ ꜜyɔ́ **bʉ̂**	'you saw the madman'

For this chapter, the most important of these will be the realization of the rising tone LH (e.), which under certain conditions the insertion of a final vowel. No other tone conditions this process. We turn to this matter now.

3 Tone-driven epenthesis

In this section, we make the case for tone-driven epenthesis in Ghomala', defined as the phonological insertion of a vowel in order to realize a pitch target. We provide two lines of evidence: from static distributions in lexical root shapes, and

from active alternations seen in multi-morphemic structures such as derivation, inflection, compounding, *et cetera*.

3.1 Static distributions: Evidence from root shapes

The first patterns to examine are the phonotactics of roots and the co-variation there between CV shape and tonal patterns. As shown above in Table 1, open syllable roots bear six contrastive tone patterns. This six-way contrast is also allowed on closed syllables with a sonorant coda /m ŋ/ (these being the only sonorants allowed in this position). This is demonstrated in Table 2.[3]

Table 2: Tones on syllables with sonorant codas

Tone	Example		Meaning	Source
H	/kɔ́m/	[kɔ́m]	'crab'	(Nissim 1981: 216)
L°	/lə̀m°/	[lə̀m°]	'condiment'	(Nissim 1981: 72)
L	/lə̀m/	[lə̀m]	'dry season'	(Nissim 1981: 72)
HL	/fâm/	[fâm]	'plantation'	(Eichholzer 2010: 16)
LH	/bə̌m/	[bə̌m]	'destiny'	(Nissim 1981: 74)

In contrast to open syllables and syllables closed by a sonorant coda, rising tones show an interesting pattern with syllables closed by an obstruent coda, which in Ghomala' are /p k ʔ/. This is shown in Table 3. In the context of a LH tone, such syllables may be realized either as a rising tone (faithful to their underlying representation) or a vowel is epenthesized to the root. In this latter variant, the L portion falls on the lexical vowel and the H portion on the epenthetic vowel. Importantly, epenthesis is not found in the other tonal contexts.

Nissim (1981) is quite explicit in treating this final vowel as epenthesis, stating that its only function is to support the tone complex (p. 65). All cases of obstruent codas show the epenthetic vowel variant if and *only* if it has rising tone. An example set is in Table 4, involving all three possible codas /p k ʔ/. With coda /p/ and /k/, an epenthetic [ə] is inserted to host the H portion of the rising tone while with /ʔ/ it is either [ə] or a copy of the root vowel. Note as well an independent process of frication (and backing) with /k/ which happens between vowels.

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[3]Note that HL tones rarely appear with sonorant codas, and the example here is ultimately a loanword (from English 'farm'). Additionally, the distinction between H and downstepped H is not always apparent (e.g. within dictionary entries), since they merge in isolation. We therefore do not make this distinction in the tables to follow.

Table 3: Tones on syllables with obstruent codas

Tone	Example		Meaning	Source
H	/káp/	[káp]	'pipe'	(Eichholzer 2010: 23)
L°	/bàp°/	[bàp°]	'animal'	(Eichholzer 2010: 3)
L	/pàp/	[pàp]	'wing'	(Nissim 1981: 218)
HL	/lâp/	[lâp]	'elegance'	(Eichholzer 2010: 31)
LH	/lăp/	[lăp]~[làpə́]	'pool of water'	(Eichholzer 2010: 31)

Table 4: Epenthesis when rising tone appears with obstruent coda

	Example		Meaning	Source
a.	/gɔ̌p/	[gɔ̀pə́]	'hen'	(Nissim 1981: 63)
	/căp/	[càpə́]	'corn cake'	(Nissim 1981: 74)
b.	/fɔ̌k/	[fɔ̀χə́]	'cold'	(Nissim 1981: 65)
	/săk/	[sàχə́]	'wall'	(Nissim 1981: 65)
c.	/gwɔ̌ʔ/	[gwɔ̀ʔə́]	'termite'	(Nissim 1981: 146)
	/lăʔ/	[làʔá]	'village'	(Nissim 1981: 74)
	/pǔʔ/	[pùʔú]	'package'	(Nissim 1981: 146)
	/gǔʔ/	[gùʔʉ́]	'strength'	(Nissim 1981: 90)

No such variation is reported among the other tonal contrasts, i.e. for forms in Table 3 there is no variation for /pàp/ 'wing' between forms [pàp] and [pàpə́] or for /lâp/ 'elegance' between forms [lâp] and [lápə́], *et cetera*. This demonstrates that epenthesis of the final vowel is not triggered by a markedness constraint against final obstruent codas.

Spectrograms of Ghomala' words and phrases pronounced in isolation confirm the presence or absence of a final vowel in these contexts.[4] The first two figures show roots with LH tones (the pitch is the red line, and pitch range is at the right). Figure 1 shows a LH tone on an open syllable, showing a clear and steady rise. In contrast, Figure 2 shows a LH tone with a coda /p/. It is clear from the spectrogram that in this context a full vowel [ə] appears after the final consonant and bears the H portion of the tone. Compare this to Figure 3 which shows a level

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[4]These recordings were provided by Larry Hyman, which were originally recorded under the direction of Gabriel M. Nissim.

low tone (L°) on a syllable closed by the obstruent /p/. Unlike Figure 2, here the /p/ is unreleased and no vowel follows it. Parallel facts hold in the recordings involving coda /k/ and /ʔ/.
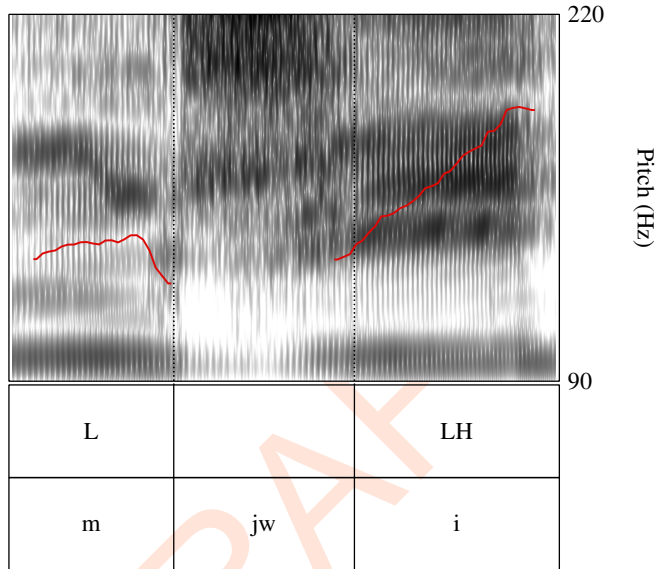

Figure 1: LH tone on open syllable – /mjwǐ/ [mjwǐ] 'woman'

Moreover, coda nasals /m ŋ/ do not show a variant with an epenthetic vowel. While (2) demonstrates that there is some variation in terms of the exact realization of a rising tone, no variant occurs with final [ə].

(2) No vowel epenthesis with sonorant codas (Nissim 1981: 74)

   a. /lǎm/   [làḿ] ~ [làáḿ] ~ [lǎm]   'drum'
   b. /lěŋ/   [lèή] ~ [lèéή] ~ [lěŋ]   'horse'

A spectrogram confirms the lack of a final vowel in such LH contexts, shown in Figure 4. It is clear that the rising portion of the pitch is realized on [ŋ] itself.

These patterns show that sonorant codas behave analogous to open syllables in permitting a rising tone realization without recourse to epenthesis. A restriction on rising tones with coda obstruents but not coda sonorants is exactly the
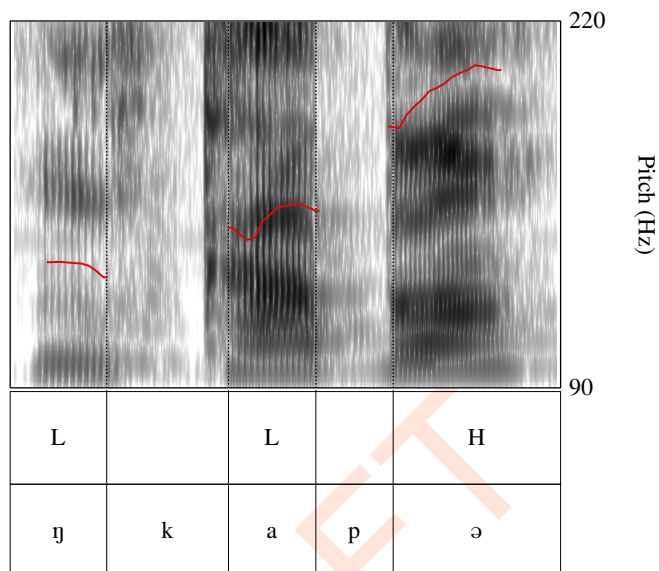
Figure 2: LH tone on syllable with coda /p/ – /ŋkǎp/ [ŋkàpə́] 'money'

type of constraint which is predicted based on previous typological surveys of contour tones (Zhang 2013). As we stated in the introduction, what is tonologically rare is not the constraint itself but rather the repair, i.e. the epenthesis operation. We return to this matter in Section 4 below.

We have thus far presented data from static distributions demonstrating covariation between a final vowel and a LH-toned root. At this juncture, we should defend the contention that this is indeed epenthesis as opposed to deletion of an underlying vowel, i.e. this is /cvc/ → [cvcə] rather than /cvcə/ → [cvc]. The first argument involves root phonotactics generally. Nissim shows that the vast majority of roots in the language are monosyllabic, either a CV or CVC shape. The exception to this statement are exactly those [cv̀cə́] forms detailed above. If we treat these at an abstract level as /cv̌c/ then this unifies the possible shape of roots.[5]

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[5]It is worth repeating the original French here: *La plupart des mots de la langue sont monosyllabiques. Rappelons qu'on doit compter parmi les monosyllabes les mots de [ton montant], de forme apparente CVCV, en réalité de forme CVC, dont la voyelle ultime est épenthétique puisque*
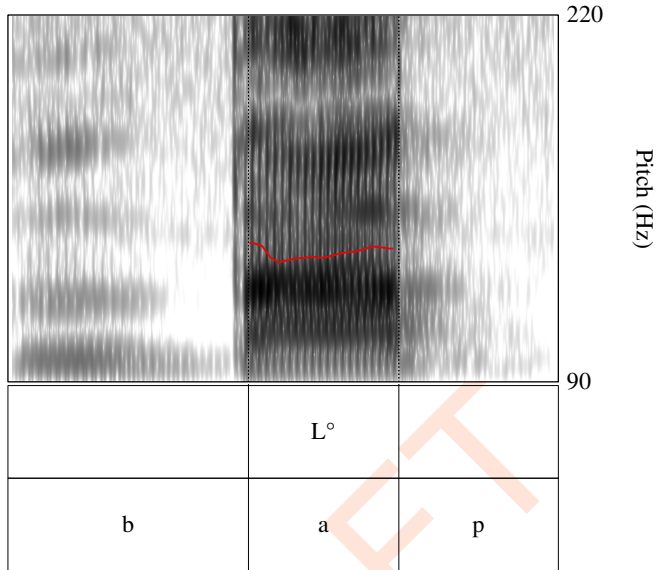
Figure 3: L° tone on syllable with coda /p/ – bàp° 'animal'

Polysyllabic words are nearly always decomposable into multiple morphs, either compounds of some type (e.g. nɔ̀m-gẅì 'panther', more literally 'animal-panther') or a derived form with a grammatical affix, such as suffixes /-nyə/ and /-tə/, or the prefix /kə̀-/.

(3) Disyllabic stems as multi-morphemic

    a. kùŋ 'love' → kùŋ-nyə̀ 'love each other' (Nissim 1981: 91)

    b. pà 'carry on back' → pà-tə̀ 'carry carefully' (Nissim 1981: 91 – *porter soigneusement, précautionneusement, p. ex. un enfant*)

    c. kə̀-lóʔ 'badly put together' (Nissim 1981: 92 – *mal ficelé*)

The remaining forms which cannot be decomposed constitute a very marginal percentage of the lexicon, including forms such as /bìyɛ́/ 'peanut', /gə̀fɑ̀/ 'corn', /kə́pák/ 'lizard', *et cetera*. To this we can add numerous loanwords from English

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sa seule fonction est de supporter la deuxième more d'un ton complexe (Nissim 1981: 90).
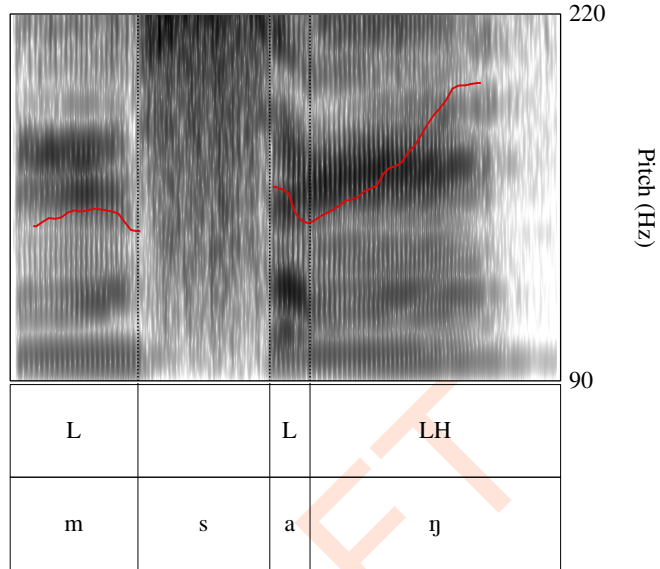
L		L	LH
m	s	a	ŋ

Figure 4: LH tone with sonorant coda – /msǎŋ/ [msàŋ́] 'birds' (ᴘʟ)

and French found in Eichholzer (2010), e.g. /bəlèŋ/ from English 'blanket' or /bàtô/ 'boat' from French *bateau*, *inter alia*.

Related to this argument is a restriction on possible vowels in syllables closed by obstruent codas. Of the vowel inventory – i.e. /i e ɛ ʉ ə ɑ a u o ɔ/ (where ɑ is IPA [ɐ]) – before coda /p/ and /k/ only the low vowels /ɔ/ and /a/ are allowed (the examples from Table 4 are representative).[6] It is clear diachronically that multiple vowel categories have merged in this context. For example, comparing Ghomala' data to Proto-Eastern Grassfields reconstructions (Elias et al. 1984), we see widespread neutralization before coda obstruents. Examples involving modern Ghomala' /ɔ/ are in (4).

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[6]A few loanwords escape this generalization, e.g. /hêp/ 'help' (Eichholzer 2010: 21).

(4) a. *-gúb́ *chicken (Elias et al. 1984: 52) > gɔ̆p~gɔ̀pɘ́ 'hen' (Eichholzer 2010: 18)

b. *-kíb́ *fingernail (Elias et al. 1984: 90) > ŋkɔ̀pɘ́ 'nail' (Nissim 1981: 198)

c. *-bóp- *fear (Elias et al. 1984: 90) > pwɔ́k 'afraid' (Nissim 1972: 43)

d. *-béb̀ *he-goat (Elias et al. 1984: 59) > pɔ̆p~pɔ̀pɘ́ 'goat' (Eichholzer 2010: 45)

Important for our argument, this constraint holds both for surface [cvp]/[cvk] forms (e.g. /bàp°/ 'animal'), as well as surface [cvpə]/[cvkə] forms (e.g. /gàpɘ́/ 'antelope'). If these forms were underlyingly /cvcə/, then we expect a wider range of vowels to be permitted since the environment for the first vowel would not be a closed syllable (i.e. we might expect roots such as */bùpɘ́/ and */gèkɘ́/). That this is not the case once again speaks to such sequences being treated as /cvc/ at some level of grammar.[7]

3.2 Active alternations: Evidence from multi-morphemic structures

Our second line of evidence involves active alternations between surface variants with and without a final [ə]. Co-variation here between tone and [ə] mirrors the static distributions in root structures and shows that it is an active part of Ghomala' grammar.

We first consider derivation, which we can use to show the parity between surface rises and forms with final [ə] in the realization of LH. In a type of deverbal nominalization, the lexical tone of root is overwritten with LH tone (Nissim 1981: 288-289), shown in Table 5. With open syllables (a.) or coda sonorants (b.), the pattern surfaces with a rising tone without complication. In contrast, the LH pattern induces an epenthetic [ə] with coda obstruents (c.), mirroring the pattern in underived roots.

Now consider [ə] alternations which emerge in complex noun phrases that condition various tonal changes. First, nouns in associative constructions involve two nouns where the first noun is the head and the second noun the modifier. Examples are in Table 6 divided based on the noun class of the head noun (two examples of H and L roots each, and all modified by /bàp°/ 'animal'). As is ubiquitous in Bantoid languages, Ghomala' has an elaborate noun class system which

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[7]In addition, disyllabic sequences with final [ə] quite commonly appear with other vowels in derived environments such as cases of suffixation (as introduced above), e.g. pútɘ́ 'to accuse' or 'to roll up, fold', from pú (Eichholzer 2010: 45-46). This shows that there is no general phonological constraint against final [ə] in such contexts.

Table 5: [ə] alternations in V→N derivation (Nissim 1981: 288-289)

a.	tɤɔ̀	'be strong'	→	tɤɔ̌	'iron'
	sú	'(to) weed'	→	sǔ	'hoe'
b.	tùŋ	'dig inside'	→	ntŭŋ	'throat'
	tɔ́m	'push'	→	tɔ̌m	'fruit'
c.	tsɤ̀ʔ	'twist'	→	dzɤ̀ʔɤ́	'liana (vine)'
	fɔ́k	'blow (cold)'	→	fɔ̀kə́	'cold'

is reflected morphologically in the shape of morphs that are in agreement with the head noun. One way this manifests is through the grammatical tone in the associative construction. In this table, class 1 nouns condition a floating low grammatical tone (Ⓛ) which links the two nouns (floating tones unassociated in the input are circled and throughout). In contrast, other classes (e.g. class 3) condition a floating high (Ⓗ). These grammatical tones result in various changes, e.g. in row a. /mú/ becomes falling [mû] while in row b. the second low tone becomes downstepped.

Table 6: Class-dependent grammatical tone (Nissim 1981: 249-250)

a. CL 1	/mú	Ⓛ	bàp°/	→	[mû bàp°]	'the child of the animal'
	/gì	Ⓛ	bàp°/	→	[gì bàp°]	'the voice of the animal'
b. CL 3	/thə́	Ⓗ	bàp°/	→	[thə́ bàp°]	'the head of the animal'
	/kwə̀	Ⓗ	bàp°/	→	[kwə̀ ↓bàp°]	'the foot of the animal'

Nissim (1981) provides extensive paradigms detailing these tonal changes, both within the associative construction as well as in other complex noun phrases (e.g. with possessive pronouns, demonstratives, indefinites, *et cetera*). We render parts of these paradigms in tone notation in the tables below, where the underlying tone of the first noun (N_1) is at the far left and that of the second noun (N_2) is in the top row. Table 7 shows the tone paradigm for association constructions involve a class 1 head noun, which condition the floating Ⓛ grammatical tone. Here the tone of N_2 remains in tact while the tone of N_1 is altered. In contrast, Table 8 summarizes those constructions involving a non-class 1 head noun (e.g. class 3 in Table 6), which condition the Ⓗ grammatical tone. Here it is N_2 whose tones are modified while N_1's remain unmodified for the most part.

The relevant portions for our examination of tone-driven epenthesis are the

Table 7: Associative tone paradigm with class 1 head noun

N_1 / N_2	H		⁺H		L°		L		LH	
H	[HL	H]	[HL	H]	[HL	L°]	[HL	L]	[HL	LH]
L°	[HL	H]	[HL	H]	[HL	L°]	[HL	L]	[HL	LH]
L	[L	H]	[L	H]	[L	L°]	[L	L]	[L	LH]
LH	[HL	H]	[HL	H]	[HL	L°]	[HL	L]	[HL	LH]

Table 8: Associative tone paradigm with non-class 1 head noun

N_1 / N_2	H		⁺H		L°		L		LH	
H	[H	H]	[H	⁺H]	[H	L°]	[H	L]	[H	⁺H]
L°	[L	H]	[L	H]	[L	⁺L°]	[L	⁺L]	[L	H]
L	[L	H]	[L	H]	[L	⁺L°]	[L	⁺L]	[L	H]
LH	[LH	H]	[LH	⁺H]	[LH	L°]	[LH	L]	[LH	⁺H]

rightmost columns involving alternations in the realization of LH tones. With class 1 nouns (with a L grammatical tone) the form surfaces as [LH], while with other classes (with H) the form is a downstepped H tone. This [LH]~[⁺H] alternation surfaces straightforwardly as such with open syllables and with coda sonorants, e.g. /bvǔ/ [bvǔ] ~ [⁺bvú] in (5).

(5)   [LH]~[⁺H] alternation
   a.   /mú L bvǔ/ → [mû bvǔ] 'the child of the dog' (Nissim 1981: 264)
   b.   /thə́ H bvǔ/ → [thə́ ⁺bvú] 'the head of the dog' (Nissim 1981: 153)

As expected, obstruent final /LH/ nouns show this same tonal alternation and the presence of a final vowel co-varies with it. Consider the noun /gɔ̌p/ 'hen' which in isolation is [gɔ̀pə́]. This form surfaces as such in the [LH] context but as [⁺gɔ́p] in the [⁺H] context without the final schwa.

Taking together the static distribution of [ə] in roots and the dynamic alternations seen in complex words and phrases, we have enough evidence to support this as a rare case of tone-driven epenthesis, where an epenthetic vowel appears in order to host part of a pitch contour (rather than due to segmental or syllabic markedness conditions).[8]

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[8]Various verbal inflectional contexts also show co-variation between tone pattern and final

Table 9: Co-variation between tone alternations and final [ə] (Nissim 1981: 157-158, 250-252)

a.	/mú	Ⓛ	gɔ̌p/	→	[mû	gɔ̀pə́]	'the child of the hen'
	/kò?°	Ⓛ	gɔ̌p/	→	[kô?	gɔ̀pə́]	'the rooster of the hen'
	/gì	Ⓛ	gɔ̌p/	→	[gì	gɔ̀pə́]	'the voice of the hen'
	/dyə̌	Ⓛ	gɔ̌p/	→	[dyə̂	gɔ̀pə́]	'the house of the hen'
b.	/thə́	⊕	gɔ̌p/	→	[thə́	ꜜgɔ́p]	'the head of the hen'
	/mkò?°	⊕	gɔ̌p/	→	[mkò?	gɔ́p]	'the roosters of the hen'
	/kwə̀	⊕	gɔ̌p/	→	[kwə̀	gɔ́p]	'the foot of the hen'
	/tǎŋ	⊕	gɔ̌p/	→	[tǎŋ	ꜜgɔ́p]	'the ear of the hen'

3.3 Support for tonal features

The tone-driven epenthesis facts support an independently-posited proposal for the tone systems of Grassfields languages: the use of tone features. Such features are used to capture the six-way distinction in (nominal) roots – i.e. /H/, /ꜜH/, /L°/, /L/, /HL/, and /LH/ – in particular those which involve modifications of H and L tones.

The most important question for our study is the following: how do we represent the distinction between /ꜜH/ vs. /L°/ vs. /LH/ tones? In individual languages, a downstepped high and a level-toned low are often treated as having floating tones before or after them to account for their contrast against plain H and L. For example, in early work on these Grassfields languages Hyman & Tadadjeu (1976: 63-65) analyze Ghomala' LH as a composite /L+H/ sequence associated to a single tone-bearing unit (for our purposes, the vowel). In contrast, ꜜH is rendered as Ⓛ+H with a floating low tone unassociated to the vowel and L° as a L+⊕ with

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vowel. Ghomala' has a basic underlying H vs. L distinction on verb roots (Nissim 1972: 79), a property it shares with other Bamileke languages (Elias et al. 1984: 62). Certain parts of the verbal system which confirm the observations in the nominal domain, e.g. for L-toned roots the imperative is expressed with LH tone realized as a rising tone on roots like [pàá] 'carry on the back!' but with a [ə] on roots like [càpə́] 'insult!' (Nissim 1972: 80). However, other parts of the system complicate our generalizations. For example, in the infinitive form H-toned roots are realized as something of a mid tone (regardless of their segmental shape), and no epenthetic vowels are found. In contrast, with L-toned roots it is realized as a high-mid tone, e.g. /cáp/ '(to) insult' becomes [šápə̄] in the infinitive (the consonant change is regular and orthogonal). This is a rare instance in the language of a final vowel being added in a tone contexts other than LH. It is unclear exactly the status of this [M] tone in the language's phonological grammar, and whether this would still be interpreted as tone-driven epenthesis. For these reasons, we have focused this chapter on the nominal system.

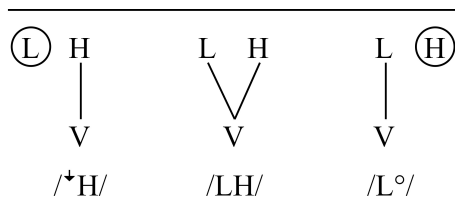a floating high. This is shown in Figure 5.

Figure 5: Three-way contrast with floating tones (*to be rejected*) (Hyman & Tadadjeu 1976: 63-65)

The shortcoming of this type of analysis is that the proposed floating tones never condition vowel epenthesis – i.e. words like /bàp°/ 'animal' are never realized as [bàpɔ́] – whereas the counterpart pre-linked tone sequence does. Why would the floating tones not cause epenthesis?

To solve this, we propose that the difference is not whether or not the tone is underlyingly linked or floating (as in Figure 5), but rather is a more ontological difference: the contrast involves distinct tonal features. A prominent theory of tonal features (and one already applied to Grassfields languages) is 'Register Tier Theory' (Snider 1988; 1990; 1999).[9] The central premise of this model is that there are two tiers which contain qualitatively distinct tonal features. One is simply the 'tonal tier' which hosts familiar tonemes such as H and L. The other is the 'register tier' containing register features, denoted with lower case h and l. These features are used to encode 'register shift' of pitch targets higher or lower compared to the previous register, specifically useful for capturing three or more contrastive pitch heights and phenomena such as downstep and upstep (Snider 1999: 25). For example, Figure 6 illustrates a four-height tone system where the highest pitch involves two features [H,h] and the lowest as [L,l], with intermediate pitches [H,l] (a higher mid) and [L,h] (a lower mid). No privative 'M' (or 'm') feature is used for mid tones, nor any other features for other degrees (e.g. for super high's or super low's).

With this geometry in mind, let us return to the Ghomala' contrast between /↓H/, /L°/, and /LH/. In Figure 7, the downstepped high tone can be represented as a [H,l] sequence (with a neutralizing rule with high tone [H,h] in isolation), while the level low tone can be represented as [L,h]. We use previously introduced words /↓dhɔ́/ 'spouse' and /bàp°/ 'animal' here.[10] Minimally different is the LH tone, which can be represented compositionally as a L tone and a H tone (each

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[9]For a history of proposals akin to Register Tier Theory, see Bao (1999).

[10]This latter representation is the one actually posited by Snider (1999: 127) for cognate L° roots
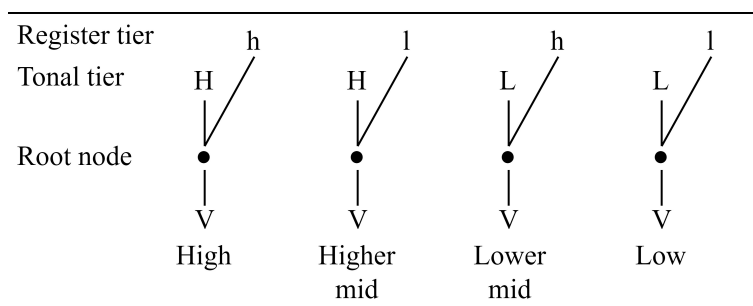
Figure 6: Four-way height contrast *via* tonal features (Snider 1999)

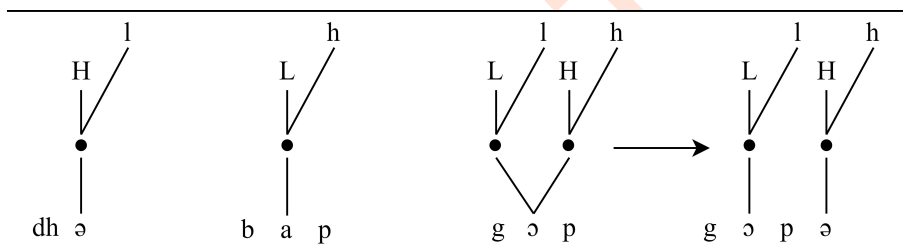with their own tonal root node), both associated to the same vowel (illustrated with /gɔ̌p/ 'hen').

Figure 7: Analysis of ↓H (e.g. ↓dhɔ́) vs. L° (e.g. bàp°) vs. LH (e.g. gɔ̌p)

The crucial difference between these representations is that although the first two have high and low components they are of different types, namely tonal tier and register tier features. In contrast, the last contains two tonal tier features associated to the same vowel, a representation to which we can localize our constraint, in (6).

(6) *[cv̌к]: A linear sequence of tonal tier features L H do not associate to a vowel in a syllable closed by an obstruent coda

In Ghomala', this constraint is repaired by inserted a minimal vowel (either [ə] or a copy vowel) to host a tonal tier feature (i.e. [H]). Because the downstepped high and level low tone contain features on separate tiers, they do not form a linear sequence and therefore (6) does not apply to them. Therefore, the decomposition of tonemes into distinct features correctly predicts that they may have distinct

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in the Grassfields language Bamileke-Dschang [ybb].

behavior and subject to different constraints, manifested here. Models without features would struggle to capture these differences.

4 Discussion

We now discuss these Ghomala' patterns with reference to the larger typology of tone and tonal rarities. First, we note that the constraint on rising tones on closed syllables is a common one, frequently found in tone systems. Second, although this is a common constraint, we highlight that tone-driven epenthesis is a virtually unattested repair in contrast to common repairs contour reduction or vowel lengthening. Lastly, we present three possible explanations (not mutually exclusive) to account for this tonal rarity: (i) low functional load of tone, (ii) analytic indeterminacy of epenthesis, and (iii) the potential for tone to find pre-existing hosts.

4.1 A common constraint: Rising contours on closed syllables

The *[cv̌ʀ] constraint of Ghomala' is part of a general cross-linguistic tendency to avoid rising contours on inadequate hosts. The phonetic underpinnings of this constraint are well-known. In his typological survey on tonal contours, Zhang (2013) notes that the main correlate of tone is fundamental frequency (i.e. f_0), and rich harmonic structures is crucial to the perception of f_0. Because sonorous segments such as vowels and sonorants possess richer harmonic structures than obstruents, they make for better tone-bearing units as the pitch targets are better perceived on them. Moreover, it is also well-known that among complex tone structures, a rising pitch takes longer to execute than a falling pitch and consequently has greater duration on average (e.g. Sundberg 1973). Taking these two aspects together, [cvʀ] structures may not provide enough sonorous material to adequately realize the rising tone within its required duration.

These inherent phonetic factors account for the general markedness of contours and especially rising contours in the world's languages. In his survey, Zhang (2013) states languages that only allow surface falling tones (n=37) far exceed languages that only allow surface rising tones (n=3). This markedness is also reflected in various implicational tendencies, e.g. the finding of Gordon (2001) that "if a language allows contour tones on CV, it also tolerates them on CVO, CVR, and CVV" (p. 428).

In response to such phonetically motivated pressures, the simplest scenario are languages which unequivocally prohibit [cv̌ʀ], and where they cannot re-

sult due to multi-morphemic concatenation. Most languages however provide evidence for two types of repairs for [cv̌ʁ]. The first is compression, simplification, or flattening of the rising contour. Zhang (2013) discusses flattening of contour tones which may result in complete neutralization with another tone – e.g. in Xhosa [xho], HL contours are merged with H tones in unstressed environments (Lanham 1958; 1963) – but in other languages may be simply compressed while preserving tonal contrast.

Particularly widespread is a second repair involving vowel lengthening, especially for rising tones. Zhang cites non-neutralizing lengthening in Mitla Zapotec [zaw] for syllables with rising but not falling contours (Briggs 1961). In the Africanist context, this is often framed as mora insertion. For example, in Gokana [gkn] genitive constructions involve the juxtaposing a head noun followed by a modifying noun (parallel to the Ghomala' patterns from Table 6), shown in Table 10. Hyman (2011: 74) shows there are no tonal changes with H- and L-toned head nouns (a.-b.), but M-toned nouns are marked with a L grammatical tone (c.). If there are enough moras to accommodate the genitive tone then it simply falls on the final one, but in monomoraic nouns (e.g. /tɔ́/ 'house') there are not enough to accommodate both tones. In this context and this context alone, a mora is added to host the genitive tone resulting in a long vowel.

Table 10: Tone-driven mora insertion in Gokana (Hyman 2011: 74)

	Tone	Head noun		→	Genitive		
a.	H	té	'tree'	→	té	nēn	'tree of person'
b.	L	gɛ̀	'knife'	→	gɛ̀	nēn	'knife of person'
c.	M	tɔ̄	'house'	→	tɔ̄ɔ̀	nēn	'house of person'
		mɛ̄n	'neck'	→	mɛ̄ǹ	nēn	'neck of person'
		mīī	'blood'	→	mīì	nēn	'blood of person'
		kīgī	'axe'	→	kīgì	nēn	'axe of person'

4.2 A rare repair: Tone-driven epenthesis

While a phonetically-natural constraint like *[cv̌ʁ] is quite common in phonological systems, as has been mentioned several times tone-driven epenthesis as a repair is quite rare if not unprecedented. No such repair appears in either of the typological surveys mentioned above (Gordon 2001; Zhang 2013), nor does it appear in reference works on tone (e.g. Pike 1948; Fromkin 1978; Yip 2002; Wee 2019;

inter alia) or on epenthesis (e.g. Broselow 1982; Itô 1989; Blumenfeld 2006; De Lacy 2006; Hall 2006; Hall 2011; *inter alia*). In fact, works which posit a maximally restrictive theory of epenthesis assume tone-driven epenthesis to be impossible (Blumenfeld 2006; Gleim 2019). Blumenfeld concludes that epenthesis is "used exclusively as a response to pressures of syllable structure, sonority sequencing, syllable contact, and word minimality" (p. 5), but that "tone conditions cannot affect string structure" and therefore tone "cannot force epenthesis/syncope" (p. 41).

To the best of our knowledge, Table 11 is the exhaustive list of all potential cases of tone-driven epenthesis, gleaned from the literature. Other than Ghomala' at the top, the most convincing case is Wamey, an Atlantic language also within the Niger-Congo phylum but very distantly related to Ghomala'. Rolle & Merrill (2022) provide a number of arguments parallel to those for Ghomala' that rising tones on closed syllables trigger epenthesis, as well supporting facts from grammatical tone. Of the other languages, Kejom (another Grassfields language) and Kifuliiru (a Bantu language) show patterns consistent with tone-driven epenthesis but are morphologically restricted rather than phonologically general, appearing in only a few contexts. In contrast, in Ghomala' (and Wamey) the pattern is robust across all morphological contexts. Finally, for both Arapaho and Hdi Gleim (2019) argues convincingly that they do not qualify as tone-driven epenthesis (see Gleim for arguments).

Table 11: Known potential cases of tone-driven epenthesis

Language	ISO	Source
Ghomala'	[bbj]	Nissim (1981); this work
Wamey	[cou]	Santos (1996); Rolle & Merrill (2022)
Kejom	[bbk]	Akumbu et al. (2020)
Kifuliiru	[flr]	Van Otterloo (2011: 71-73)
Arapaho	[arp]	Cowell & Moss (2008: 16)
Hdi	[xed]	Frajzyngier (2002)

4.3 Why is tone-driven epenthesis so rare?

These facts beg the question: why is tone-driven epenthesis so rare, if not unprecedented? Its existence in Ghomala' (and Wamey) shows that we cannot prohibit it absolutely (e.g. via Universal Grammar conditions on phonological archi-

tecture), and several superficially similar phenomena exist which are not particularly rare. For example, a counterpart to tone-driven epenthesis is 'tone-driven vowel retention' whereby vowels that are otherwise expected to delete and/or reduce are retained if and only if they bear tone. This is in fact the counter-analysis of Gleim (2019) for Arapaho. Roettger & Grice (2019: 279-280) identify several other cases of tone-driven retention in lexical accent/tone systems (e.g. Cheyenne, Acoma, Konso, Shanghainese, Japanese), and describe a parallel 'intonation-drive vowel retention' in numerous languages (e.g. Standard European Portuguese, Bulgarian, Greek, Ath-Sidhar Rifian Berber, Moroccan Colloquial Arabic, Bonaara Oromo, and Tunica). It is therefore strange that the epenthesis counterpart should be so rare, especially in tonal languages.

4.3.1 Explanation 1: Little need for contrast preservation

The first avenue of explanation for the rarity of epenthesis has to do with contrast, specifically that for many tone languages there is little reason to excessively maintain tone contrast. In other words, the 'functional load' of tone is typically quite low.[11]

In tonal languages, the majority of tone-specific morphs are expressed jointly by tonal and segmental material. If there is enough segmental material to differentiate the morph from other paradigmatically-related morphs (e.g. all nominal roots), then the cost of adding more segmental material might outweigh the cost of being faithful to the underlying tone pattern. In this way, tone is expendable. In tonal languages, therefore, if a [cv̌κ] sequence is encountered little information would be lost for correctly identifying the intended meaning target if the H portion were simply deleted.

We can contrast this to intonation where an epenthetic process is more commonly proposed (especially gradiently). The 'intonemes' of intonational systems canonically do not occur with segmental co-exponents, and one consequence of this is that the functional load is much higher here. Losing cues for the intonational melody is thus more costly and to avoid this (post-lexical) epenthesis appears to be a reasonable repair.

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[11]Note however that quantitative studies proving this in a typologically balanced sample of tonal languages has yet to be undertaken. Compare also Chinese languages like Mandarin where tone *does* have a pronounced functional load, comparable to vowel distinctions (Surendran & Levow 2004).

4.3.2 Explanation 2: Analytic indeterminacy of epenthesis

Relatedly, the rarity of epenthesis may be attributed to the propensity for the epenthetic vowel to be reinterpreted as underlying (and therefore no longer epenthetic). A surface form like [gɔ̀pə́] 'hen' from Ghomala' may be reinterpreted as underlying /gɔ̀pə́/, while in comparison this reinterpretation is less likely in intonation because the segments and the intonational melody contribute different meanings.

However, even within intonation-driven epenthesis it is often not straightforward whether to interpret a final 'epenthetic' vowel as derived or underlying. In the above-cited Tunisian Arabic (1), Hellmuth (2022) deliberates over the final [ə] which co-varies with the complex rise-fall intonation, ultimately concluding that it is "rather a 'question vowel' particle of some type", analogous to similar interrogative clitics in the area. The analytic indeterminacy of epenthesis is notoriously difficult (Morley 2015), which applies to both linguists and speakers.

To avoid reinterpreting an epenthetic vowel as underlying, a language requires some other counteracting force. In Ghomala' this force is the relatively strict conditions on root phonotactics which prohibit multi-syllabic roots as well as the active alternations (e.g. in Table 9).

4.3.3 Explanation 3: Intonation is more 'edge-bound' than tone

Our final point concerns a positional asymmetry between (lexical) tone and intonation. Morphs carrying lexical tone may appear in various positions in a clause while intonation is often bound to a specific edge, e.g. the right edge of the intonational clause. The consequence of this is that lexically-sponsored tone has more opportunity to dock to surrounding material (e.g. words to its right) than edge-bound intonation. By docking to an already existing vowel, this obviates the need for epenthesis.

In tonal languages, this often manifests as a contrast between plain L-toned words versus L-toned words which sponsor a floating high tone ⊕ after them. One such language is Ganza [gza] (Smolders 2016), where this contrast can be seen in noun possession. In (7), L-toned /kùrù/ 'genet' (an animal) causes no changes to the following words (no general grammatical tone occurs between nouns in this language), while L-toned /wàŋà/ 'chicken' additionally sponsors a

⊕ which docks to the following word.

(7) Floating tone in Ganza docks to word to right (Smolders 2016: 134-135)
   a. /kùrù   tòkò/ → [kùrù tòkò]   'genet's foot'
   b. /wàŋà⊕ tòkò/ → [wàŋà **tókò**]   'chicken's foot'

Smolders is explicit that the floating ⊕ "either attaches to an available tone-bearing unit (TBU) or is deleted" (the realization as a rising tone is quite limited – see Smolders 2016: 128, fn 40).

   In total, lexically-sponsored tone have several potential targets, and certainly more than in intonational systems which are edge-restricted.

5 Conclusion

This chapter focused on a little-known tonological rarity: tone-driven vowel epenthesis. We showed that in Ghomala', an epenthetic vowel is inserted to avoid a rising tone on syllable closed by an obstruent, i.e. /gɔ̌p/ → [gɔ̀pɔ́] 'chicken', but never triggered in other tonal contexts. That this is tone-driven epenthesis is supported by active alternations in the language which show that when a rising tone is changed the epenthetic vowel is lost, illustrating complete co-variation between tones and segments. While the motivation for this process is quite common and well-known in the literature – namely avoiding a rising tone on a sub-optimal host – the repair itself (i.e. epenthesis) is virtually unprecedented in the tone literature. We discussed three explanations for its rarity, specifically contrasting it against intonation where it has been found more often: (i) the low functional load of tone, (ii) the analytic indeterminacy of epenthesis, and (iii) the potential to find pre-existing hosts. We conclude that these factors conspire together to make tone-driven epenthesis a tonological rarity.

Acknowledgements

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